A web-based DSS for resource allocation in a Brazilian public University

Martins Carolina Lino[1, 2], Zaraté Pascale[1], De Almeida Adiel Teixeira[2], Morais Danielle Costa[2], Peters Kurt Costa[3]

[1]IRIT – Toulouse Capitole University – 2 rue du Doyen Gabriel Marty 31042 Toulouse Cedex 9 – France

carol_tcch@hotmail.com, Pascale.Zarate@irit.fr

https:// www.irit.fr/

[2]UFPE - Production Engineering Department, Federal University of Pernambuco Av. Acadêmico, Hélio Ramos, s/n, Cidade Universitária, Recife-PE, Brazil

almeida@cdsid.org.br, daniellemorais@yahoo.com.br

http://www.cdsid.org.br/

[3]UFMS - Production Engineering Department, Federal University of Mato Grosso do Sul – Av. Costa e Silva, s/n, Bairro Universitário, Campo Grande – MS, Brazil

kurtpeters87@gmail.com

ABSTRACT

This study aims to demonstrate how a web-based Decision Support System (DSS) can improve the process of internal resource allocation in a Brazilian public university as part of a bigger research project that aims to build a web-based DSS for internal resource allocation in all Brazilian public universities. To achieve its goals, the analysis was carried out by developing a DSS Database model to store and retrieve data, defining the user's interface based on his detailed requirement analysis and using a web application to transform the prototype into a web-based system. Currently, there aren't any general DSS for such a problem. All data for the application of the model are gathered manually and managed by a single department at the University studied. The idea is that the system could support decision makers, stakeholders that are part of the process, decentralize tasks achievement, besides improving communication, collaboration, increasing productivity of group members and improve data management using the Web. The perspectives are to contribute to the decision problem of how to improve the allocation resources process correctly faced by the university analyzed. In addition, it could be used to provide background for the Federal Universities strategic resource allocation planning.

Keywords: Decision Support System, Web-based DSS, Resource Allocation, Budgeting, Model-driven DSS

INTRODUCTION

The effective use of scarce resources is a crucial problem for universities in general and particularly in Brazil, where public universities perform an important role. The process of allocating internal resources in Brazilian federal universities (FU) among administrative units has become increasingly challenging and depends on a diversity of legal, economic, structural, and organizational parameters [1].

One of the FU goals it is to improve the provision of beneficial results for the society interest, considering an increasingly complex and changing environment. Within this context, Turban *et. al*. and Power [2, 3] affirm that circumstantial evidence suggests that Decision Support Systems (DSS) can improve decision quality and change the structure and functioning of organizations.

By definition, a Decision Support System is as a computer-based information system that supports decision makers use data and models to solve semi-structured and unstructured problems. It helps decision makers to make better decisions, to answer complex questions [4, 5] and it is considered essential to support the decision-making process [5].

All kinds of DSS can be implemented using Web technologies and can become web-based DSS. Managers progressively have web access to data warehouses and analytical tools [6]. A web-based DSS, thus, bring decision support information or decision support tools to a manager or business analyst using a "thin-client" Web browser like Internet Explorer that is accessing the Global Internet or a corporate intranet. Its application can increase access and use, reduce support and training costs and allow extensive capabilities to the users [7] and that is the reason its applicability will be considered for this research.

Hence, the propose of this work is to present a web-based Decision Support System (DSS) for internal resource allocation in a Brazilian public university once it could improve communication, collaboration, increase productivity of group members (there are 21 sectoral administrative units that are affected by the allocation procedure) and improve data management using the Web [6]. To do so, the survey was divided into four steps: identify and analyze the allocation model from the Federal University chosen; collect data and compile them into Excel spreadsheets; create a Database model and, finally, create a prototype of the web-based system.

Presently, there aren’t any general DSS for such a problem. All data for the application of the model are gathered manually and managed with Excel spreadsheets by a single department at the University studied. The idea is that the system could support decision makers, stakeholders that are part of the process and decentralize tasks achievement, since web-based DSS provide the availability of intelligent search tools that could enable them to find and manage the information they need quickly and inexpensively [2].

As a suggestion, the general concept of the web-based DSS presented here could be extended and applied by other federal universities in Brazil or other countries, adapting the alternatives and criteria for each specific internal allocation model and to the Decision Makers (DM) needs with the same purpose of improving the decision-making process.

The case study conducted in this work is part of a bigger research project that aims to build a web-based DSS for internal resource allocation in all Brazilian public universities. The research project started with the design of the DSS and for more complete information on this research, see: [8].

Also, to state a clarification, the main decision of the model (not the problem situation of this study) it is how to improve the resource allocation process and the Decision Maker considered is the representative director of the budgeting unit from the Federal University of

Mato Grosso do Sul (UFMS), because of the availability of data and similarity to a general model in Brazil.

The Brazilian federal university analyzed in this research has 21 sectoral administrative units (called UAS or AU) that are divided by areas, such as human sciences, biological sciences, engineering, faculty of medicine, etc., and each one of them has an annual budgetary requirement. The university has 5287 employees (divided between academic, technical and administrative staff) and around 27 thousand students (from undergraduation and graduation courses). The aim is that the application of a correct DSS to distribute the local budget between these units can contribute to the University's permanent strategy of efficient and fair resource allocation.

SURVEY

To create the web-based DSS for UFMS, four phases of the decision-making process were considered [9, 10]: (1) intelligence, based on the identification, definition and understanding the problem; (2) design phase, that analyses possible courses of action for the problem; (3) choice, which involves a solution model, validations and tests; and, finally, the (4) implementation phase, that implements the chosen alternative and monitors the solution.

After the intelligence and design phase, in where the aim was to understand how the resource allocation model from the Federal University of Mato Grosso do Sul works, the variables from the model, how they are calculated and how the budget is allocated internally, data were collected and compiled into Excel spreadsheets, a Database model was developed, using SQL language, the user's interface was defined, and, finally, a prototype of the web-based system was implemented, with a PHP language.

Every year, the UFMS budget and planning department (PROPLAN) sets the criteria to allocate the budget credits from the Ministry of Education OCC Matrix (Other Cost and Capital – OCC), applicable to all sectoral administrative units, which should be strictly used for costing and investment activities. Every UAS provides data and information, based on the parameters described below, to the budgeting unit. PROPLAN gathers the information and then sets the percentage of the budget that will be distributed to each UAS, based on the resource allocation model. The distribution of the budget credits is founded on quantitative and qualitative variables, described as follows:

- Quantitative variable (IVQuan): based on the number of equivalent students from each UAS (InAlEqv), calculated from indicators related to the number of students entering, enrolled and graduating from undergraduate (TAEG), postgraduate courses (TAEM and TAED), and medical residences (TAERM). The indicator also considers information about the subject area of the course, for example, a medical course is more expensive than a history course because of the number of laboratories needed, thus, the course has a weighting factor, and takes into account the total duration of the course too;
- Qualitative variables (IVQual): based on criteria that measure the efficiency / effectiveness of the Unit, in terms of academic staff qualification (IQCD), number of vacancies (IVO) and that's the only criterion to be minimized, research projects with external financial support (IPP), extension projects with external financial support (IPE), graduation success rate (ITS), teaching efficiency (IDEAE), measured by the relation between the total number of students and professors, quality of the undergraduate (IDGQ), master (IDQM), and doctorate (IDQD) courses, based on the evaluations from the National Institute of Studies and Educational Research Anísio

Teixeira – INEP and the Coordination for the Improvement of Higher Education Personnel - CAPES.

Thus, the formulas of the model are calculated as it follows and detailed information could be seen in [11]:

$$\text{InPP UAS} = \text{IVQuan} + \text{IVQual} \quad (1)$$

Where:

$$\text{IVQual UAS} = \sum \text{IQCD} + \text{IVO} + \text{IPP} + \text{IPE} + \text{ITS} + \text{IDEAE} + \text{IDQG} + \text{IDQM} + \text{IDQD} \quad (2)$$

$$\text{IVQuan} = \text{InAlEqv} = \sum \text{TAEG} + \text{TAEM} + \text{TAED} + \text{TAERM} \quad (3)$$

WEB-BASED DSS PROTOTYPE IMPLEMENTATION

The DSS case study proposed here focuses on a model-driven DSS, and according to Power's [12] DSS framework, can be classified as it follows: the dominant DSS component is an optimization model based on a resource (budget) allocation procedure; the target users are the administrative staff from the budgeting unit of UFMS and Decision Makers from every UAS, since they are affected by the allocation procedure; the purpose is to contribute to the decision question of how to improve the resource allocation process properly and to optimize it; and the enabling technology used was Excel, resource allocation model, creation of the basis to build a web-based DSS, Database model and web-based DSS.

The creation of the DSS is justified by the fact that all data for the application of the model are gathered manually and managed with Excel spreadsheets by a single department at the University studied, from data provided by each UAS. The idea is that the system could support decision makers, stakeholders that are part of the process, improve data management, communication, collaboration, increase productivity, decentralize tasks achievement, access information at any time and from anywhere, analyze and interpret it [2].

The DSS Prototype from the model found by this study is presented in Figure 1, where the information can be visualized as it follows: the inputs are data from the model (provided by the UAS, filled and stored at the Database), such as the name of the UAS and the indicators or parameters considered by the model; the processing are the interactive processing of data and models, the calculation of the formulas defined by the models, the simulation, optimization and analysis that can be provided by the models; lastly, the outputs are the final share of the budget that each university, academic unit or course will receive, the transformed data from the models that can be used to take decisions. The processing and outputs steps are performed in the web system. The end users are the administrative staff from the budgeting unit of UFMS and DM from every UAS.

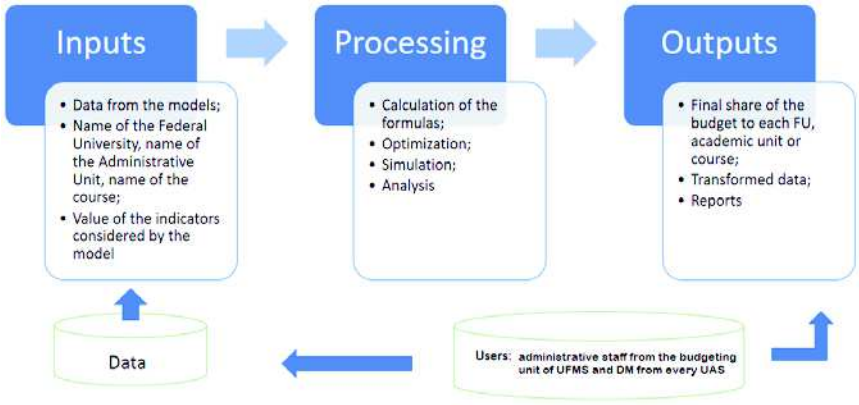

Figure 1: DSS components of the prototype from this research

To implement the web-based DSS a PHP web application was developed on the server side and a Database system MySQL was applied to store and retrieve data using Structured Query Language (SQL). Next, Figure 2 shows the Database Model and Figure 3 shows the PHP pages from the user interaction.

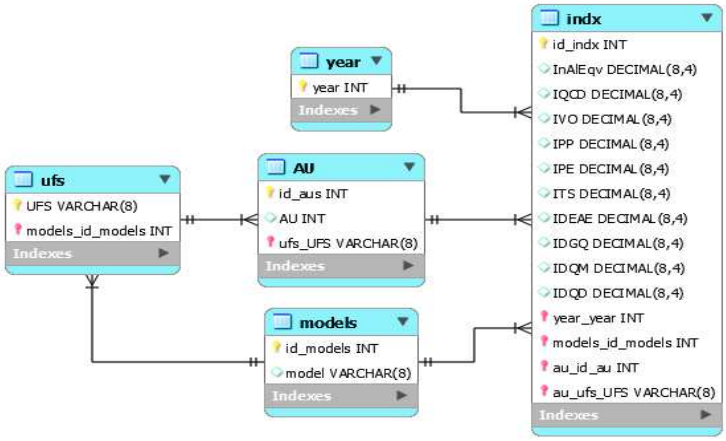

Figure 2: Database model

Figure 2 shows the Database model structure in where the information is stored and used by the web system. The "indx" table contains most of the foreign keys, biding with year, type of model, administrative unit (au) and with university (ufs). With AU table association, for example, the connection type is 1-to-n, that means, one AU can have n indx associate with, and the same rule is applied for the year, models, and university tables (ufs) with AU.

Figures 3 shows the user interface based on his detailed requirement analysis. Page 1 is the year selection page in where the user can select all year options at the database (2015 / 2016). Page 2 is the university selection page. In this case, there is only one selection option: UFMS. Page 3 shows all the information from every administrative unit, such as their indexes, percentage of the budget and the name of the AU. Also, the user can change the indexes values and the available budget to simulate different scenarios. That is the most important part of the system, because it allows the users to estimate the budget that they could have in case of changing some parameters of the model. From this information every unit can establish an action plan in order to improve its indexes and, consequently, increase its percentage of budget share. Finally, Page 4 shows the percentage of the budget in financial terms too, the possibility of simulating the results with a different budget and a histogram to show the results in a visual way.

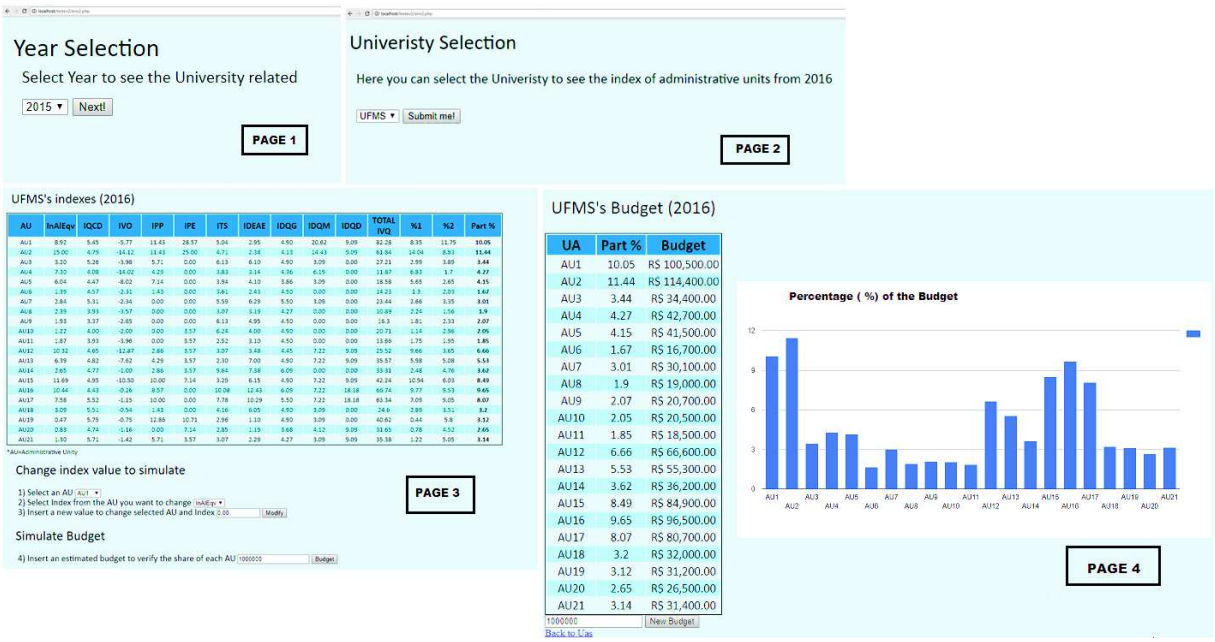

Figure 3: Web system pages – user interface

PERSPECTIVES AND CONCLUSION

The purpose of this study was to present a web-based Decision Support System (DSS) for internal resource allocation in a Brazilian public university as part of a bigger research project that aims to build a web-based DSS for internal resource allocation in all Brazilian public universities [8]. Currently, there aren't any general DSS for such a problem. All data for the application of the model are gathered manually and managed by a single department at the University studied (and this situation happens for several others Federal Universities in Brazil).

The idea is that the system could support decision makers, stakeholders that are part of the process, decentralize tasks achievement, besides improving communication, collaboration, increasing productivity of group members (there are 21 sectoral administrative units affected by the allocation procedure) and improve data management using the Web.

To achieve its results, the work developed a DSS Database model to store and retrieve data, defined the user's interface based on his detailed requirement analysis and used a web application to transform the prototype into a web-based system.

Finally, the program can be tested by the users and the last web-based DSS version can be implemented. The system still must be improved to be useful for the users. The idea is that a web-based DSS for the problem presented here can increase access and use, reduce support and training costs and allow extensive capabilities to the users [7].

Also, as a suggestion, the concept of the DSS presented here could have potential expansions in the future, expanding its general prototype to be used by the Ministry of Education in Brazil or others public institutions with the similar decision problem.

The perspectives are to contribute to the decision problem of how to improve the allocation resources process correctly faced by Brazilians public universities, take safer and reliable decisions, seeking to reduce uncertainties and to maximize their results. In addition, it could be used to provide background for the Federal Universities strategic resource allocation planning.

It is worthwhile to note that the DSS prototype has no production intention but to deal with as an experiment with only research purposes. In addition, the research was limited to study the effects that a system could have on the process of internal resources allocation and it

was not the focus to verify if the budgeting model considered is suitable or not. Thus, as a suggestion for future works, it would be interesting to consider models that could also be appropriate for the type of problem presented here, as multicriteria decision making (MCDM) methods.

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